

AMENDMENTS TO THE SPECIFICATION

Please amend the paragraphs starting on page 1, line 2 (numbered line 1) and ending on page 9, line 13 with the following:

BACKGROUND

The invention relates to a method of placing at least one component on at least one substrate, ~~wherein the component is picked-up a component being picked up by means of at least a placement machine and placed on a desired position on the substrate. The invention also relates to a system suitable for executing such a method.~~~~the method as claimed in one of the preceding claims. [sic]~~

~~In such a One such method and system known from United States patent US A- are disclosed in U.S. Patent No. 5,880,849 in which an image of a substrate is made by a camera. From the image thus made image, a desired position relative to the substrate of a component to be placed on the substrate is established. Then Then, the placement machine is driven and the component is placed on the substrate. By means of the of this method and system known per se system, however, it is not possible to carry out a check to find out impossible to check to see whether the component is really placed on the substrate at the on the desired position.~~

SUMMARY

An Therefore, it is an object of the present invention to provide a method in which by which the placement of a component on a substrate can be improved in a simple manner.

This object is achieved by the method according to the invention in that after the component has been placed on the substrate, an image of the component placed on the substrate is made by a camera. Any camera, a difference between the actual real position of the component on the substrate and the desired position of the component on the substrate being is then established on the basis of the image, after which image. Subsequently, the positioning of a next component to be placed is adapted to account for any such difference. on account of the difference found.

From the image produced by means of the camera, the actual real position of the component relative to the substrate can be determined in a simple manner. Any difference is then established between the desired and actual real positions of the component placed on the substrate. If the component is correctly positioned on the substrate, there will not be any be no substantial difference between the desired and actual real positions of the component on

the substrate. However, if there is a difference indeed exists, in the method according to the invention, the this difference is taken into account by the for the placement machine drive when positioning another a next component is positioned on the substrate. The camera can either form part of the placement machine or form part of a device set up next to or at a distance from the placement machine. Finding the difference between the actual real and desired positions as well as adapting a positioning of a next component based on the difference found, may take place both on line and off line online and/or offline.

According to an embodiment of the method according to the invention is characterized in that present invention, first a same kind of component is placed on a number of substrates on substantially at substantially the same positions, while positions and differences between the desired and actual real positions of the components relative to the associated substrates are determined, the determined. The positioning of a next component to be placed on a next substrate is then being adapted on account of the differences found (if any) identified. In this manner manner, deviations between the desired and actual real positions of the component due to incidental deviations, for example deviations due to what are called stochastic errors such as (e.g., friction in the placement machine, dynamic vibrations, measuring error etc. error, etc.) over a number of substrates are processed when the identified when positioning a subsequent of a next component. However, if an error repeats is adapted and an error remains which will repeat itself at nearly every substrate. This substrate, this error is for example (which may be, e.g., the result of calibration rest errors, the stretching of the substrate due to temperature changes, machine wear, errors in a relatively large number of the same substrates relative to the expected and actual real location of for example of, for example, track patterns on a substrate etc. Errors like these are etc.) is called a deterministic errors. error. When the deviations are processed identified, deviations in substrates that were have already been manufactured earlier are counted less strongly than deviations in a substrate that has been was manufactured just before the substrate now to be provided with components.

According to a further embodiment of the method according to the invention is characterized in that first present invention, first on at least one substrate a number of different components are positioned on at least one substrate. The actual, the real positions of which the components are compared with the with desired positions thereof, subsequent to which the positioning of a next component to be placed on the substrate or another substrate is adapted based on a statistically determined average difference. In this way the way, the

differences are determined of may be determined of, for example, example all of the components placed by a certain placement machine.

According to a further embodiment of the method according to the invention is characterized in that present invention, once a number of components have been placed, the real positions are actual positions may be compared with the desired positions. In this way this way, determining the actual real position of the component relative to the substrate can take place independently of the placement of the component on the substrate. A disadvantage of this approach, however, is that not until a number of components have been placed will there be established whether these components have really been positioned ~~on the desired position at the desired positions, thereby creating the desired and only after that will a feedback be realized.~~

According to another embodiment of the method according to the invention is characterized in that present invention, once each component has been placed, the actual real position is compared may be compared with the desired position. In this way there is way, there may be a direct coupling once a component has been placed. If the time for determining the difference between the actual real and desired positions of the component is relatively short, this approach does not have a disadvantageous effect on the time necessary for placing the component.

According to yet another Yet another embodiment of the method according to the invention is characterized in that present invention, components may be placed are placed on at least a substrate by means of a number of placement machines located side by side, each side-by-side. Each placement machine comprising includes, among other possible things, a camera by means of which an image of at least a portion of the substrate is produced to determine the difference between the desired and actual real positions of the component placed on the substrate. In this way it is possible to examine a portion of the substrate by means of each camera, thereby enhancing which enhances accuracy whereas the time required for analyzing each image remains relatively limited.

Another object of the present invention is The invention also has for an object to provide a system with which components can be placed on a substrate more accurately.

This object is achieved with the system according to the invention by the present invention. The system is being provided with at least a placement machine and a camera that cooperates cooperating with the placement machine, an machine. An image of a component positioned on a substrate by means of the placement machine being producible by means of may be produced by the camera, the camera. The placement machine is further being

provided with a control scheme by means of which a difference between an actual real position and a desired position of the component relative to the substrate ~~as well as a difference with a desired position of the component relative to the substrate~~ can be determined from the image produced by the camera. In this ~~manner~~ manner, a difference between the actual real position and the desired position of a component on a substrate can be determined in a relatively simple manner. If the placement machine already has a camera, for example, for determining the desired position on the substrate with the camera, an image can be made by the same camera both prior to and subsequent to the placement of the component, i.e., ~~another and no separate camera does not need~~ needs to be added to the placement machine.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only, and are not restrictive of the invention as claimed.

#### BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present invention will become apparent from the following description, appended claims, and the accompanying exemplary embodiments shown in the drawings, which are briefly described below.

~~The invention will be further explained with reference to the drawings in which:~~

Figs. 1-5 show plan views of various embodiments of systems according to the ~~invention, invention;~~

Figs. 6A-6C show plan views of a system according to the invention, the figures showing substrates ~~on the~~ at different positions, positions;

Fig. 7 shows a perspective view of a system according to the ~~invention, invention;~~

Figs. 8A-8D show different ways of analyzing an image, image;

Fig. 9 shows a control ~~diagram~~ protocol of a method ~~where in which~~ feedback takes place ~~in line, online;~~ and

Fig. 10 shows a control ~~diagram~~ protocol of a method ~~where in which~~ feedback takes place ~~off line offline~~ offline.

#### DETAILED DESCRIPTION

Efforts have been made throughout the drawings to use the same or similar reference numerals for the same or like components. Like components in the Figures are denoted by like reference numerals.

Fig. 1 shows a system 1 for placing components on a ~~substrate, which~~ substrate. The system 1 comprises three placement machines 2', 2", 2''' located ~~side by side~~ side-by-side.

The substrates to be provided with the components are transported through the system 1 in the direction indicated by arrow P1 by means of a transport system 3. Such a system is known per se from United States patent US A 5,880,849 mentioned above disclosed in previously mentioned U.S. Patent No. 5,880,849 and will, therefore, therefore not be further explained.

Downwards of the system 1 is located a machine a device 4 that has a camera 5 by means of which images of a substrate provided with components can be produced. The images made by the camera 5 are fed to a control-diagram protocol 6 (Fig. 9). The positions of components placed on the substrate relative to the substrate are determined by means of the control-diagram protocol 6. The control-diagram protocol 6 further contains the desired positions 8 in a unit. In element 83 the 83, the difference between the desired positions 8 positions and the actual real positions, which are stored in a unit 7, is determined by means of the control-diagram protocol 6. The difference  $E = Y - E = \Delta Y$  is subsequently fed to a controller 9 included in the control-diagram protocol 6. In the, in which controller 9, after filtering by a low-pass filter 10, a feedback signal 12 is calculated by means of a calculation algorithm 11. The feedback signal 12, which feedback serves to adjust the control of the individual placement machines 2', 2'', 2''''. The difference E may include both deviations in X, Y and N-direction. This feedback signal 12 may be adjusted per machine. In this way it way, it is possible to increase the accuracy with which a next component is placed on a next substrate. In the embodiment shown in Fig. 1, the systems system 1 and the device 4 form separate systems are separate entities.

In the embodiment shown in Fig. 2 shows an embodiment in which the machine device 4 is integrated with the system 1 and is installed adjacent to placement machines 2', 2''. The functioning of the system shown in Fig. 2 corresponds to that shown in Fig. 1.

Fig. 3 shows another embodiment of a system 21 according to the invention which that comprises three adjacent placement machines 22', 22'', 22''''. Each of the placement machines 22', 22'', 22''' is which are each provided with an associated camera 23', 23'', 23''' as well as a control-diagram protocol belonging to each camera. By means of the system 21 shown in Fig. 3, the deviation between the actual real position of the component and the desired position is determined by means of the camera 23', 23'', 23''' present in the associated machine 22', 22'' and 22''' immediately after the placement of component on a substrate. In this way this way, there is a direct feedback signal 12.

Fig. 4 shows an embodiment of a system 31 according to the invention which that comprises a system 1 shown in Fig. 1, a placement machine 32 installed beside it and a

~~system device 4~~ installed beside the latter. The operation of the system 31 shown in Fig. 4 corresponds to the system shown in Fig. 1. An advantage of such a system 31 is that not each individual placement machine 2', 2'', 2''', 32 needs to have a camera. A disadvantage, however, is that from a substrate on which a component has been placed by means of a placement machine 2', ~~the actual the real~~ positions of the components are not determined by means of the ~~machine~~ device 4 until ~~already~~ a relatively large number of other substrates have been provided with components by placement machine 2'. In ~~this way this way~~, feedback is relatively slow.

Fig. 5 shows yet another embodiment of a system 41 according to the invention in which a system 42 is installed between the system 1 comprising placement machines 2', 2'', 2''' and the ~~system 4, with device 4~~. With the aid of ~~the which~~ system 42 the 42, the component placed on the substrate is affixed to the substrate. Such a system 42, such as, for example a wave soldering device, is known per se and will, therefore, ~~therefore~~ not be further explained. While the component is placed on the substrate, undesired displacements of the components relative to the substrate may occur, which ~~which~~ are not caused by placement inaccuracies.

Figs. ~~6A-6C~~ 6A-6C show the system 21 represented in Fig. 3, in which each placement machine 22', 22'', 22''' comprises an associated camera 23', 23'', 23'''. This system 21 largely corresponds to the system known from ~~United States patent US-A-5,880,849. In the system shown in that patent U.S. Patent No. 5,880,849, in which the~~ cameras 23', 23'', 23''' are used only for determining a desired position of a component on the substrate and not for determining the actual real position of the component on the substrate subsequent to the placement of the component on the substrate.

In the situation shown in Fig. 6A, three substrates 24', 24'', 24''' are located in the system 21. For simplicity, ~~the substrates~~ the substrates show both the components 25 already ~~27-29~~ already placed and the components 25 still to be placed. Once the substrates 24', 24'', 24''' have been situated in the placement machines 22', 22'', 22''', a pick-up device 26 mounted beside the camera 23' picks up a component from a feeding device (known per se) by the displacement of the pick-up device 26 (and ~~and~~ the camera going with it in it) in the directions shown by the arrows X, Y. Then, Then a desired position ~~on the~~ on a substrate 24'''-24' is determined with the aid of the associated camera 23'-23'''. Subsequently, after ~~which~~ the component is placed on the substrate by means of the pick-up device 26. Then an image of a portion of the substrate 24'-24''' is made by means of the camera ~~23-23'''~~ 23'-23'''. This may be the portion on which a component is placed by means of the respective

placement machine, but it is alternatively possible during the displacement of the pick-up device 26 and the associated camera 23'-23"" to make several substrate images of portions that ~~accommodated components already at an earlier time~~ ~~already contain components~~. In the situation shown in Fig. 6A, ~~an 6A-~~ an image of the component 27 on substrate 24" is made by camera 23', an image of the component 28 on substrate 24" is made by camera 23", ~~and~~ an image of the component 29 on substrate 24' is made by camera 23"".

~~Then, as shown in Fig. 6B,~~ the substrates 24'-24"" are moved in the direction indicated by arrow P1 after which the substrate 24" is largely located in the ~~placement~~ machine 22", the substrate 24"" is largely located in the ~~placement~~ machine 22' and partly in the placement machine 22", ~~and a~~ ~~and a~~ new substrate 24"" is partly located in the placement machine 22'. Subsequently, components are placed on the substrates 24"-24"" by means of the pick-up devices 26. ~~Subsequently, after which the camera 22' the camera 23'~~ produces an image of the component 51 on substrate 24""", the camera 23" ~~produces~~ an image of the component 52 on substrate 24""", ~~and the~~ ~~and the~~ camera 23"" produces an image of the component 53 on the substrate 24". ~~As a result, positions~~ ~~Positions~~ of measured components on substrate 24" can be corrected when components are placed on substrate 24""". This provides a relatively fast feedback.

After the substrates have again been moved in the direction indicated by the arrow PI, the situation shown in Fig. 6C is obtained. ~~In like manner as the manner previously described above,~~ a camera 23' produces an image of a component 54 on substrate 24""", a camera 23" produces an image of a component 55 on substrate 24""", ~~and a~~ ~~and a~~ camera 23"" produces an image of a component 56 on substrate 24"".

~~From the images thus produced can now be established from for example substrate 24"~~ ~~produced, the actual position of both component 52 and component 56 relative to the substrate 24"" can be established.~~ In the situation shown in Figs. 6A-6C, ~~each each~~ camera produces only one image of a single substrate. ~~Of course, It may be obvious that while the cameras 23"-23"" are moved over a substrate in the XY plane, various images can be produced. By means of a control-diagram protocol these images are then may then be combined to create a complete image of a single substrate, thereby providing so that information about the positioning accuracy of a number of components on a substrate can be obtained.~~

Fig. 7 shows a perspective view of a system 61 according to the invention. ~~Although the system 61, which largely corresponds to the system shown in Fig. 1 with Fig. 1, a separate, camera-equipped machine 63 is being installed side-by-side side by side with a~~

placement machine 62. The embodiment shown in This-Fig. 7 clearly shows that producing an image of a substrate 24' and determining possible corrections therefrom can only have an effect on a substrate that is located totally on the left left, in the situation shown in Fig. 7, Fig. 7. The system 61, however, does not effect but cannot have an effect on the three substrates 24 situated therebetween. As a result, the feedback signal 12 is relatively slow but does occur.

Figs. 8A-8D show a similar image 71 from which, however, the desired information, which is dependent can be derived in dependence on the desired positioning accuracy, the desired speed etc., can be derived. In the image 71 shown in Fig. 8A, the 8A the arrows 72 indicate that, for from each of the components 25 present on the substrate 24, the actual the real position of the component 25 relative to the substrate 24 is determined. Then, in Then in the control-diagram protocol 6 the actual real position of each component 25 is compared with the desired position. Of course, It may be evident that such a process requires may require a relatively large amount of much calculation time in the control-diagram protocol 6.

Therefore, it is alternatively possible to determine, as is shown in Fig. 8B, the actual real position relative to the substrate 24 of only a few components 25. The amount of information to be fed to the control-diagram protocol 6, which information is shown by means of arrows 73, is considerably smaller than in the situation shown in Fig. 8A. Preferably, Preferably the components 25, whose are then selected whose positioning accuracy has to be relatively great to guarantee a proper functioning of the substrate 24, are then selected.

In the situation shown in Fig. 8C, the 8C the arrows 74, 75, 76 indicate that only the actual positions real position of a number of components 25, which is determined which are positioned by means of the placement machines 22', 22'', 22''', are determined. In this way it is possible to individually optimize the accuracy of each placement machine 22', 22'', 22''' by means of statistics (e.g., an average per placement machine).

In the situation shown in Fig. 8D, the 8D the image 71 is obtained from joining images produced by means of separate cameras 23', 23'', 23'''. In this way no way, no extra camera is needed to produce the image 71, but use can be made of cameras 23', 23'', 23''' already present in the placement machines 22', 22'', 22'''. The information 77 obtained from the individual images images, as well as the joint image 71 can 71, can be relatively extensive. This method is particularly suitable if the measuring time and processing time is longer than the time necessary for placing a component on a substrate.

It is alternatively possible to produce a number of different images of different regions of different substrates by means of a single camera. Subsequently, from which, subsequently, a joint image is assembled may be assembled from all of the images.

Fig. 9 shows a control-diagram protocol 6 of an in-line online situation where in which components are placed on a substrate by means of a system 1. After placement of the components, after which images of the components placed on the substrate are produced by means of a machine the device 4. Information 81 relating to the desired positions of the component on the substrate is fed to the control-diagram protocol 6. These desired nominal positions are stored in a unit 8. The desired positions are corrected via the feedback signal 12, after which the value U thus obtained is fed to the placement machines 2', 2'', 2''''. These placement machines 2', 2'', 2''' are shown by block 82 in the control-diagram protocol 6. Components are positioned on the substrates on the basis of this information. Deviations owing to, for example, friction, measuring errors, wear and vibrations may then occur. Deterministic errors are part of the placement process, for example (e.g., the placement process shows may show adjustment errors errors). Subsequently, images of the component's actual position are produced by the machine device 4. This is shown as block 7 in Fig. 9. During the production of the images deviations n2 occur which images, deviations n2, which may be the result of measuring noise and calibration errors when the camera is positioned over the substrate, may occur. In an adding element 83, the actual 83 the real component positions relative to the substrate calculated from the images are compared with the desired component positions relative to the substrate known from unit 8. The resulting difference  $E = Y - E = \Delta Y$  is fed to a low-pass filter 10 and then processed in unit 11, after which a feedback signal 12 is obtained. In adding element 84 this 84, this feedback signal 12 is then combined, as previously described above, with information 81 with regard to the desired position of components on a substrate.

If a relatively large amount of information is to be processed, which may be which is impossible for example within a period of time necessary for placing components on a substrate, it may be better to it is better to not produce images for detecting deviations between actual real and desired positions of components on a substrate offline rather than online, on line, but off line. This method, as well as well as the control-diagram protocol 91 necessary for this method, is shown in Fig. 10. The control-diagram protocol 91 largely corresponds with the control-diagram protocol 6, which is shown as shown in Fig. 9, except that the device 4 is not installed, as shown in Fig. 1, near the system 1. Instead, the device 4 is but is completely separated from it from system 1. For example, the device 4 can The

~~device 4 can for example be installed in a separate laboratory. Of course, as a result of It may be obvious that the offline off line detection of differences between actual real and desired positions of components on a substrate, a relatively large time delay is obtained may result between the moment of placing the components are placed on the substrate and when then the adaptation of the driving of the placement machines is adapted for component placement on a next substrate.~~

It is alternatively possible to both verify the positions of a limited number of components ~~in line online~~ and verify the positions of all components ~~off line offline~~.

It is possible to ~~process~~ process, in the algorithm 11, ~~information information~~ of the ~~actual real~~ and desired positions of a specific component ~~as it as it~~ is positioned on a number of substrates. This ~~provides as it were~~ ~~may provide~~ an average over time of the ~~actual real~~ and desired positions by the use of, for example, digital filters.

Given the disclosure of the present invention, one versed in the art would appreciate that there may be other embodiments and modifications within the scope and spirit of the invention. Accordingly, all modifications attainable by one versed in the art from the present disclosure within the scope and spirit of the present invention are to be included as further embodiments of the present invention. The scope of the present invention is to be defined as set forth in the following claims.